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Opposition Splint for Partial Thumb Amputation: A Case Study Measuring Disability before and after Splint Use

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ABSTRACT

Study Design: Case report.

Introduction: A combined burn and a partial amputation can be extremely debilitating as the thumb constitutes 40% of the entire hand when evaluating functional impairment.

Purpose of the Study: Measure disability with and without opposition splint use after partial thumb amputation due to a burn.

Methods: Impairment and disability measures were completed at discharge from the hospital and subsequently during outpatient follow-up visits while wearing and not wearing a thumb opposition splint at 3, 6, 8, and 15 months. Comparisons between disability and impairment scores were assessed over time.

Results: The difference between DASH scores with and without using the splint were 25 at 3 months, 16 at 6 months, 10 at 8 months, and 12 at 15 months.

Conclusions: Splint use in this case demonstrated clinically significant changes over time with minimal changes in impairment indicating enhanced function and improved patient perception of disability.

Level of Evidence: 4

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A severe burn of the hand and fingers alone is a clinical challenge. When this is compounded by a partial thumb amputation, the outcome can be extremely debilitating as the thumb constitutes 40% of the entire hand when evaluating functional impairment.[1] A major component of rehabilitation after an amputation is early mobilization to reduce hypersensitivity, enhance range of motion, and minimize strength loss. Slow healing wounds and short residual digit length can limit early participation in rehabilitation. Early fitting of permanent prosthetic thumbs cannot be properly achieved in the presence of edema, open wounds, or a lack of durable soft tissue coverage (Figure 1).

Disability is described as an activity limitation or restriction in participation of a task.[2] Disability from amputation can be improved with prosthetic and adaptive devices used during activities of daily living (ADL). Literature regarding temporary prosthetic devices for individuals with thumb amputations is limited. Our literature search uncovered only three descriptions of such devices.[3–5] Reed et al. described a silicone opposition post as one of these thumb replacement solutions.[3] A second report, by Shim et al., described using low temperature thermoplastic material to fabricate a thumb post as a precursor to a permanent prosthesis in a patient with a thumb and index finger disarticulation.[4] The final article, by Bender, described a permanent prosthesis using plastic laminates as a prehension post.[5] However, none of these reports measured patient disability. Because disability can result after impairment, we compared the Disabilities of the Arm, Shoulder, and Hand (DASH) disability score to American Medical

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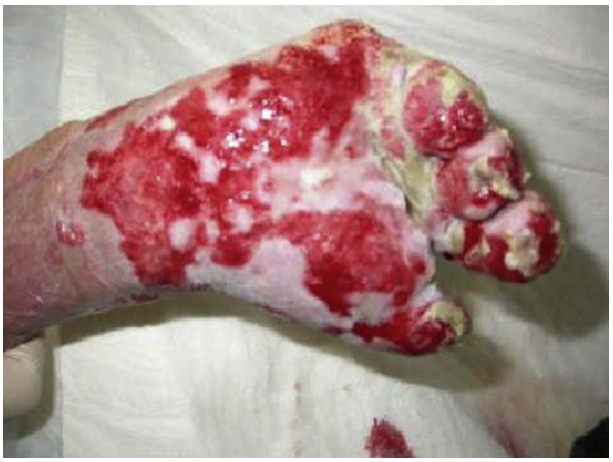

FIGURE 1. *Edematous acute amputation of right hand with poor soft tissue coverage.*

Association (AMA) impairment scores while making attempts to mitigate impairment and disability throughout recovery.

Measuring disability is an important aspect of an outcome assessment after an amputation of the upper extremity.[6] The DASH is a well-established outcome instrument used to measure disability in patients with upper extremity injuries.[7,8] The DASH is a standardized, 30-item patient completed outcome questionnaire that assesses function and symptoms. The DASH is scored on a scale from 0 to 100, with a score of 0 indicating no disability and 100 reflecting severe disability.[9] The AMA Impairment Guidelines, 5th edition, provides a well-documented and reproducible instrument for evaluating permanent impairment. Both of these instruments have been shown to be reliable, valid, and responsive in the burn population.[10,11]

The smallest change in an outcome measurement that is perceived to be important is defined as the Minimum Clinically Important Difference (MCID).[12,13] Recent studies have shown the MCID for the DASH to be a change in score that is greater than 15.[14] A Minimally Detectable Change (MDC) is the required

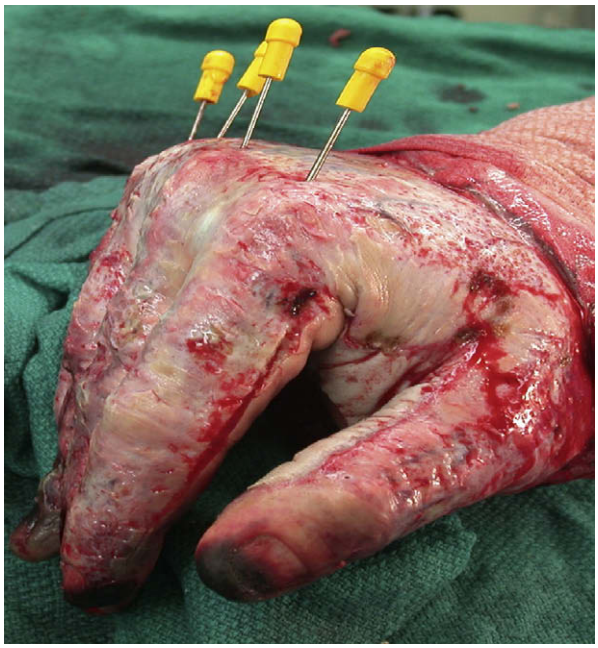

FIGURE 3. *Acute amputation with Kirschner wires in place.*

change in a score that must be exceeded to indicate a change in a patient's status, rather than a measurement error.[8] The Minimally Detectable Change 95 (MDC95) indicates a minimal detectable change at the 95% confidence interval.[8] The MDC95 for the DASH has been reported to be 12.7.[8]

In this case study, we describe a thumb opposition splint fabricated to facilitate the early functional demands of a patient with partial thumb loss. The AMA was used to measure impairment, the DASH was used to measure disability, and we report improvements in function with use of this splint device.

METHODS

A single patient case study was performed to describe the efficacy of a splint intervention used on a subject with complex upper extremity injuries. The

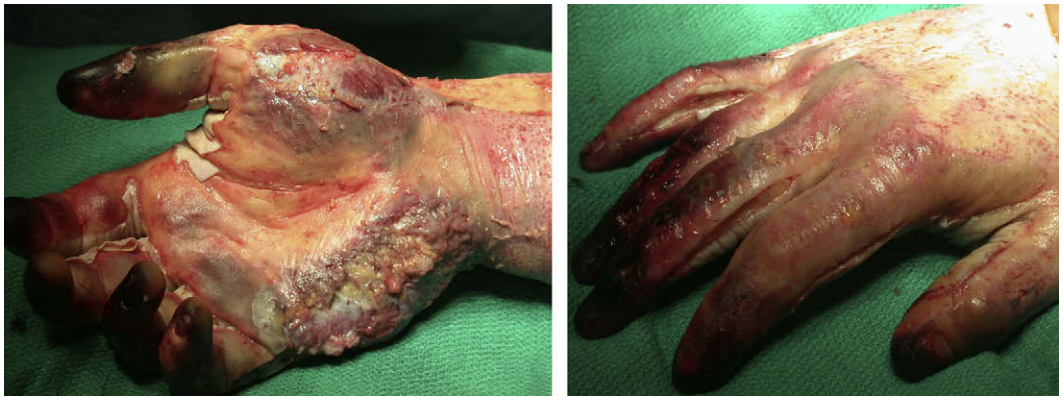

FIGURE 2. *Right-hand burn before partial hand amputation.*

TABLE 1. **Upper Extremity Therapeutic Interventions during Inpatient Hospitalization**

Intervention	*Inpatient*	*Frequency/ Duration*
Splinting	1. Right elbow flexion splint (static progressive)	6–8 h/d
	2. Bilateral hand resting splints (forearm based)	Night only
Compression	1. Coban™ (3M, St. Paul, MN) to bilateral hands	16 h/d
	2. Elastic compression right upper extremity	16 h/d
Range of motion (active and passive)	1. Bilateral hands (all joints)	BID
	2. Bilateral shoulders	
	3. Bilateral elbows	
	4. Bilateral wrists	
	5. Bilateral forearms	
ADL training	1. Upper and lower extremity dressing	QD
	2. Feeding	
	3. Toileting	

BID = twice/day; QD = once/day; ADL = activities of daily living.

patient is a 47-year-old, right-hand dominant male who suffered a 34% total body surface area burn with concomitant injuries secondary to a blast. The burn depth was partial thickness to his head and full thickness to his right axilla, right arm, right forearm, bilateral dorsal, and palmar hands (Figure 2), back, buttocks, and bilateral thighs and legs. Other injuries included a right buttock soft tissue defect, left distal femur fracture, left comminuted distal ulna fracture, right comminuted fibula fracture, and right upper extremity and bilateral lower extremity compartment syndromes requiring fasciotomies. No significant past medical history was reported.

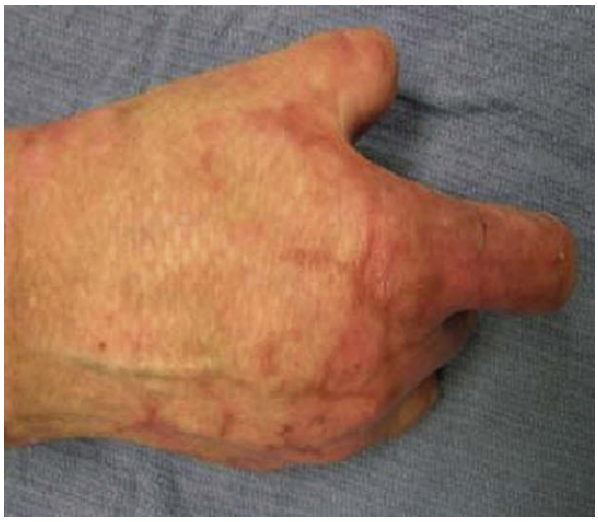

FIGURE 4. *Healed right hand with partial thumb amputation.*

Burn wound excision and split thickness skin grafting were performed at postburn day 5 to all involved areas including bilateral dorsal hands. TransCyte® (Advanced Biohealing, La Jolla, CA) was placed on bilateral thenar and hypothenar eminences. Kirschner wires were also placed at this time to position the finger metacarpophalangeal (MCP) joints in approximately 70 degrees of flexion bilaterally (Figure 3) as well as full interphalangeal joint extension on the left index, middle, and ring fingers. Two weeks later, the patient underwent a right thumb partial amputation just distal to the MCP joint and partial finger amputations of the right index, middle, and ring fingers at the proximal interphalangeal (PIP) joint level and MCP disarticulation of the right small finger (Figure 1). The Kirschner wires were removed from

TABLE 2. **Upper Extremity Therapeutic Interventions as an Outpatient Pre- and Postopposition Splint Intervention**

Intervention	*Preopposition Splint*	*Postopposition Splint*	*Frequency/Duration*
Splinting	1. Right elbow flexion splint	1. Right elbow flexion splint	6–8 h/d
	2. Bilateral resting hand splints	2. Bilateral resting hand splints	Night only
		3. Opposition splint right hand	With activity
Compression	1. Coban™ bilateral hands	n/a	16 h/d
	2. Elastic compression right arm	n/a	16 h/d
	3. Custom garments: bilateral hands/ upper extremity (after wound closure)	Custom garments: bilateral hands and right upper extremity	23 h/d
Range of motion (active and passive)	1. Bilateral hands (all joints)	1. Bilateral hands (all joints)	QD
	2. Bilateral shoulders	2. Bilateral shoulders	
	3. Bilateral elbows	3. Bilateral elbows	
	4. Bilateral wrists	4. Bilateral wrists	
	5. Bilateral forearms	5. Bilateral forearms	
Desensitization	Bilateral hands	Bilateral hands	QD
Serial casting	n/a	Left hand PIP flexion	BIW
Modalities	Moist heat to bilateral hands	Moist heat to bilateral hands and right elbow	QD
Functional activities	1. Pinching and grasping	1. Pinching and grasping	QD
	2. Light strengthening bilateral hands	2. Moderate-to-heavy strengthening bilateral hands	QD

QD = once/day; BIW = twice/week; PIP = proximal interphalangeal.

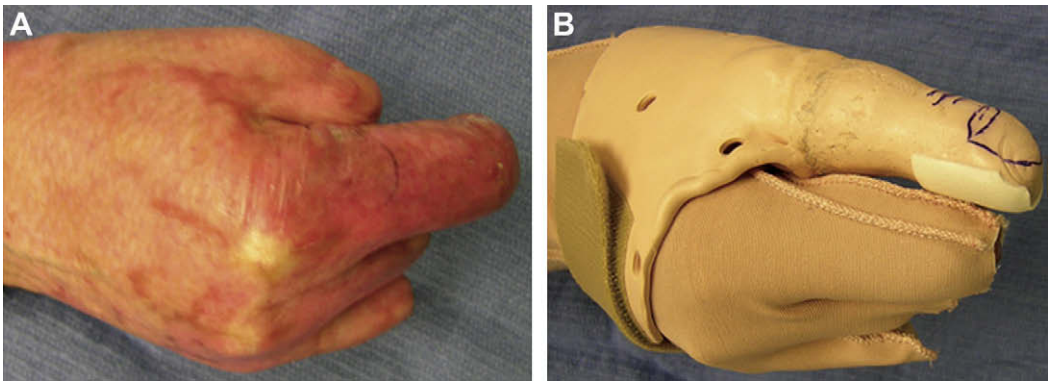

FIGURE 5. A. *Thumb opposition without splint.* ***B.*** *Thumb opposition with splint.*

both hands on the 53rd postoperative day. The patient required four additional skin graft procedures to provide coverage of all burn wounds with final grafting of the right hand on postburn day 63. The patient was discharged from the hospital 77 days after admission. The patient's postinjury course was complicated by the development of right elbow and left forearm heterotopic ossification, burn scar contracture of bilateral first web spaces, and PIP joint extension contractures of the left index, middle, and ring fingers.

The patient received therapy daily as an inpatient and outpatient therapy five times a week after discharge from the hospital. During 77 days of hospitalization, he received a total of 200 treatment sessions. Over the course of one year of outpatient therapy, he attended 216 appointments. Tables 1 and 2 summarize upper extremity interventions performed during therapy. DASH and impairment ratings were included as part of his evaluation and periodic reassessments. After three months of outpatient treatment and no significant functional improvement demonstrated by the patient, a thumb opposition splint was fabricated as the patient's primary complaint was his inability to use his right hand due to the short length of the thumb (Figure 4). A temporary device was constructed and revised until the optimal position and shape of the splint were identified (Figure 5).

The opposition splint was fabricated using Aquaplast® and PolyFlex II® splint materials (Sammons Preston Rolyan, Bolingbrook, IL). Details of the splint fabrication process are presented in Figure 6 and Table 3. Additionally, Microfoam™ (3M, St. Paul, MN) was placed distally on the volar portion of the splint to increase friction and improve pinch during functional use (Figures 7 and 8).

In this report, changes in DASH scores were evaluated using a MCID of 15 and a MDC95 of 13. The DASH was completed at hospital discharge, before and after using the thumb opposition splint, and during subsequent follow-up visits at three, six, eight, and 15 months postdischarge from the hospital. Typically, the DASH is completed to assess a patient's perception of activities performed within the past week. However, the DASH in this case was completed after using the splint for two hours to assess the immediate effect of the splint. Additionally, the DASH was completed during periodic reassessments over a 15-month span during which the patient continually used the opposition splint.

The patient's upper extremity impairment was also assessed to provide objective measurement criteria for comparison to the subjective DASH data. Impairment scores were calculated using the Greenleaf EVAL™ (Specialty Therapy Equipment, Inc, Towson, MD) computer evaluation system with AMA Impairment Guidelines, 5th edition, software.[1] The system attributes a percentage of impairment to amputation level, loss of sensation, loss of motion at each joint, and loss of grip and pinch strength to yield a percentage of the patient's upper extremity contribution to total body impairment. The impairment scale ranges from 0 to 84, where 0 indicates no impairment and 84 reflecting severe total body impairment.

RESULTS

The patient's initial DASH score was 65 at discharge from the hospital and 78 at a follow-up visit three months later. After fabrication, fitting, and initial practice using the opposition splint, the difference between DASH scores with and without using the splint were 25 at three months posthospital discharge, 16 at six months, 10 at eight months, and 12 at 15 months (Table 4). The patient reported no pain when using the splint.

The patient's upper extremity contribution to total body impairment was 70 upon splint fabrication, 63 at six-month follow-up, 69 at eight-month follow-up, and 66 at 15-month follow-up. The mean impairment score was 68 ± 3 throughout recovery. Figure 9 reveals a relationship between DASH and impairment scores during the early stages of recovery.

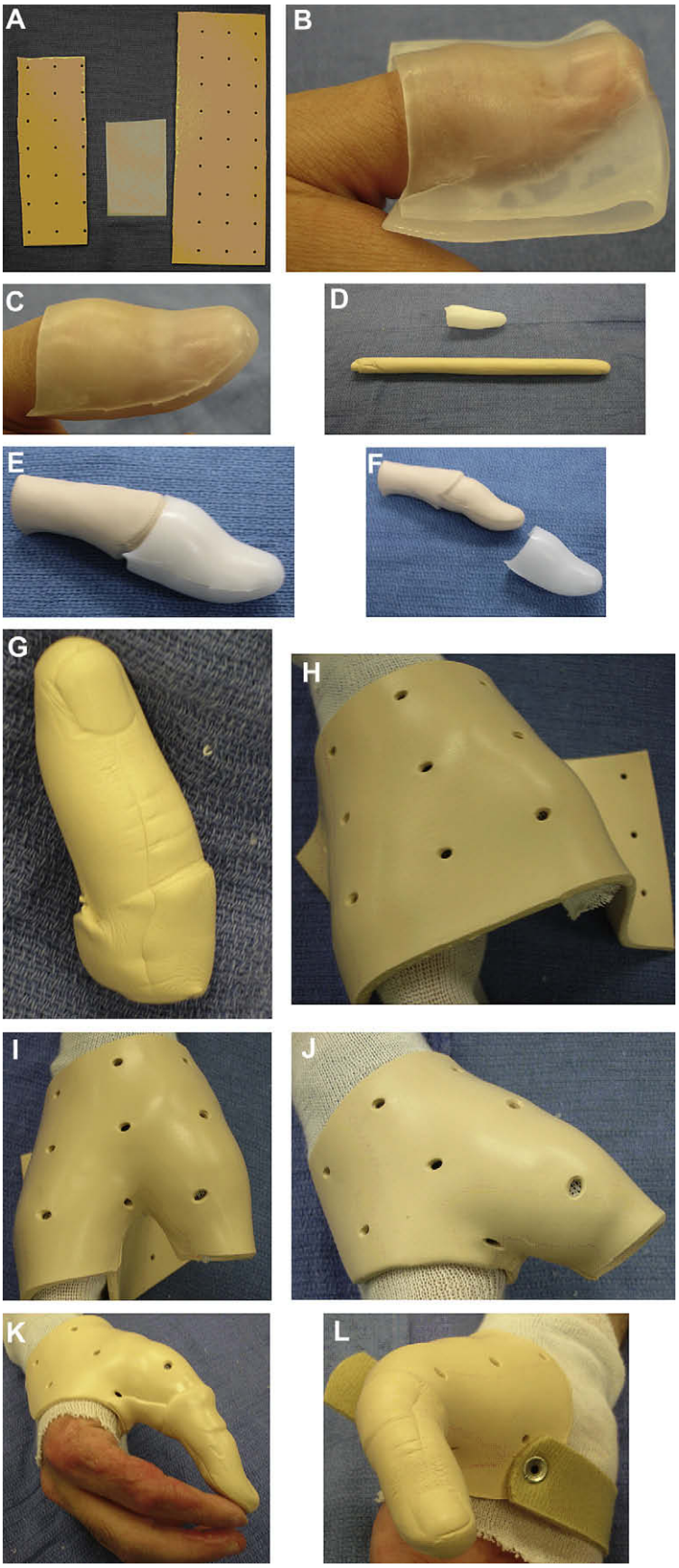

FIGURE 6. *Fabrication of the opposition splint.* ***A.*** *Thermoplastic materials used prefabrication.* ***B.*** *Thumb template molding.* ***C.*** *Trimmed thumb template.* ***D.*** *Rolled thermoplast and completed thumb template.* ***E.*** *Thermoplastic material inserted into thumb template.* ***F.*** *Thermoplastic material removed from thumb template.* ***G.*** *Completed thumb mold.* ***H.*** *Thumb base fabrication: placing material around thumb and hand.* ***I.*** *Thumb base fabrication: trimmed thumb piece.* ***J.*** *Thumb base fabrication: trimmed to allow MCP flexion of fingers.* ***K.*** *Attached thumb post to thumb base (different patient pictured).* ***L.*** *Strap attached to splint with rivet.*

TABLE 3. **Splint Fabrication Instructions**

Step	*Title*	*Description*
1.	Thumb template fabrication	Use thin thermoplastic material to form shell over uninvolved thumb, trim and let harden (see Figures 6B and 6C).
2.	Thumb postfabrication	Use a different thermoplastic material of choice and roll into a shape slightly less in diameter than the thumb template and insert this piece into the thumb template while warm (see Figures 6D and 6E). (This shapes the post to be similar to the uninvolved thumb.) Remove when cooled, details may be engraved on warm material using thumb nail (Figures 6F and 6G).
3.	Thumb base fabrication	Use same thermoplastic material as in step 2 to form around the residual thumb (~1 cm past distal tip of residual thumb) and dorsal/palmar hand. If more stability is needed include the ulnar side of the hand to the dorsal hand at the ring finger. Trim to allow full metacarpophalangeal and wrist range of motion and let harden (see Figures 6H and 6J).
4.	Thumb postplacement	Use dry heat to melt the base of the post and attach the post to the distal end of the thumb base, ensure optimal position to allow opposition with the index and/or middle finger (see Figure 6K).
5.	Strap placement	Secure strap attaching the two ends of the thumb base (see Figure 6L).
6.	Skin inspection	Ensure there is no excessive pressure at distal end of residual thumb at the attachment site of the thumb post.
8.	Friction application	Apply materials at tip of thumb post to enhance friction and allow improved pinch against splint (see Figure 7).

DISCUSSION

Even partial amputation of the thumb constitutes a severe functional deficit for a patient. Prosthetic thumb replacement can improve a patient's ADL skill; however, evaluation of a patient over time is imperative to assess the effectiveness of any device. The patient's initial DASH score was 13 points less at discharge from the hospital compared to three months later (Table 4). Among our burn and trauma population, some patients tend to believe they can perform better at living activities than they actually can. After discharge, they attempt to perform functional activities and gain a new perspective on their capabilities, which is reflected in their initial follow-up outpatient visit.

Before fabrication of the thumb opposition splint, the patient was severely disabled as measured by the DASH. Soon after fabrication of the splint his disability improved by over 60%, with a 25-point decrease in the DASH, within two hours of splint use. The patient improved an additional 16 points after three weeks of use. The patient's improved DASH scores of 25 and 16 points, at three and six months, respectively, exceeded both the established MCID and MDC95 for the DASH.

No further significant changes in DASH scores were observed during one year of splint use; however, the patient was able to sustain improvements in disability with an improved change score of 12 points after 12 months of splint use. After one year of splint use, his DASH score was 44 without the splint and 32

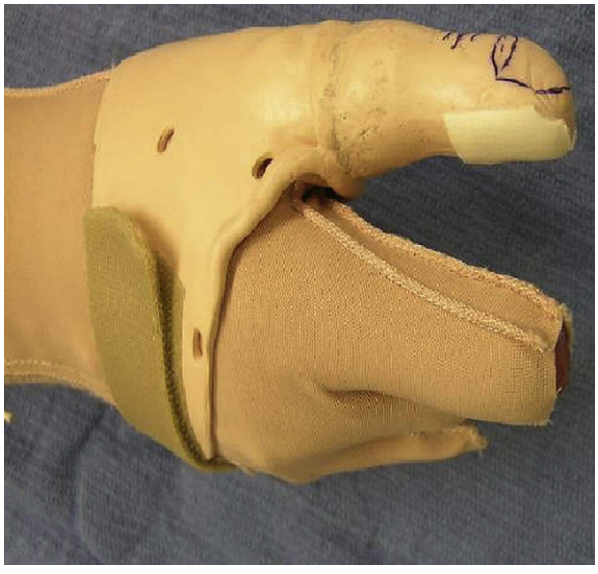

FIGURE 7. *Thumb opposition splint fitted to hand. Microfoam™ used at thumb tip to improve friction.*

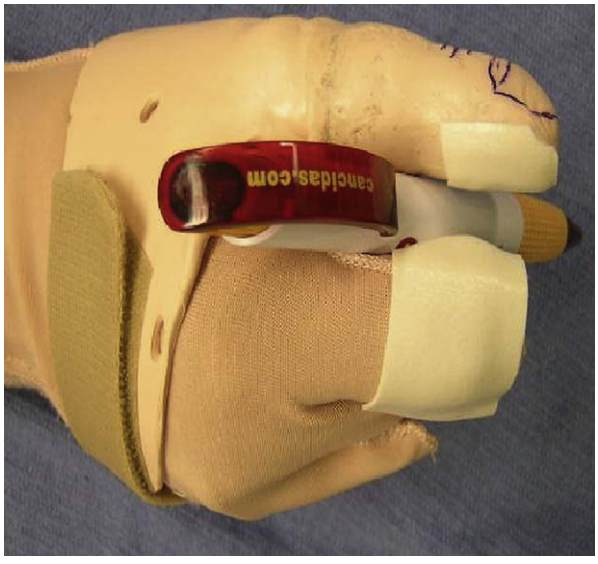

FIGURE 8. *Patient demonstrating writing skills with use of thumb opposition splint. Microfoam™ used at finger and thumb tip to improve friction.*

TABLE 4. **Disability Over Time with and without Splint and Relationship to Impairment**

Follow-up	*DASH (No Splint)*	*DASH (Splint)*	*Change in DASH*	*AMA*
Hospital discharge	65	Presplint	Presplint	71
Three months	78	53	25*	70
Six months	45	29	16*	63
Eight months	38	28	10	69
Fifteen months	44	32	12	66

AMA = American Medical Association; DASH = Disability of the Arm, Shoulder, and Hand; MCID = Minimum Clinically Important Difference; MDC95 = Minimally Detectable Change 95.
*Greater than MCID and MDC95.

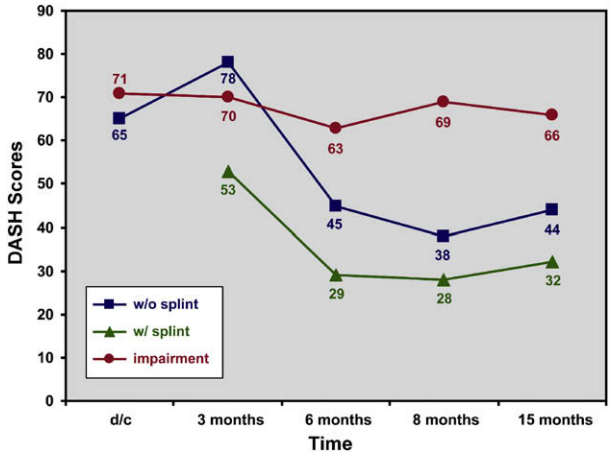

FIGURE 9. *Comparison of disability (Disability of the Arm, Shoulder, and Hand score) over time with and without splint and relationship to impairment (American Medical Association/Greenleaf EVAL™).*

when wearing the splint, a difference of 12 points. Fluctuations in the DASH score observed throughout the year were attributed to reconstructive surgical procedures to the right hand and elbow.

In the current case study, opposition splint use resulted in a DASH score change that exceeded the level of MCID and MDC95 at the two-hour and three-week intervals. Comparison of the different DASH scores without and with use of the splint over time reveals a smaller difference after one year of splint use than during the initial period of use. Although this difference did not exceed the MCID or MDC95 levels, the patient reported continued improved function with splint use. Several specific ADL activities were self-reported by the patient as noticeably enhanced with the use of the thumb opposition splint (Figure 10).

Our data revealed an apparent linkage between DASH monitored levels of disability and AMA impairment scores during the early stages of recovery. We further observed that this linkage between the AMA and DASH become uncoupled over time as the potential to improve impairment began to plateau while corresponding DASH scores continued to decline as the patient learned to cope, adapt, and compensate with and without the use of the splint (Figure 9).

Several limitations of our data have been identified. First, as is the nature of a case study, our sample population consists of a single patient and as such our findings cannot be generalized to the entire target population. Patients with differing demographic and injury characteristics may experience much different results with the use of the splint. Second, the

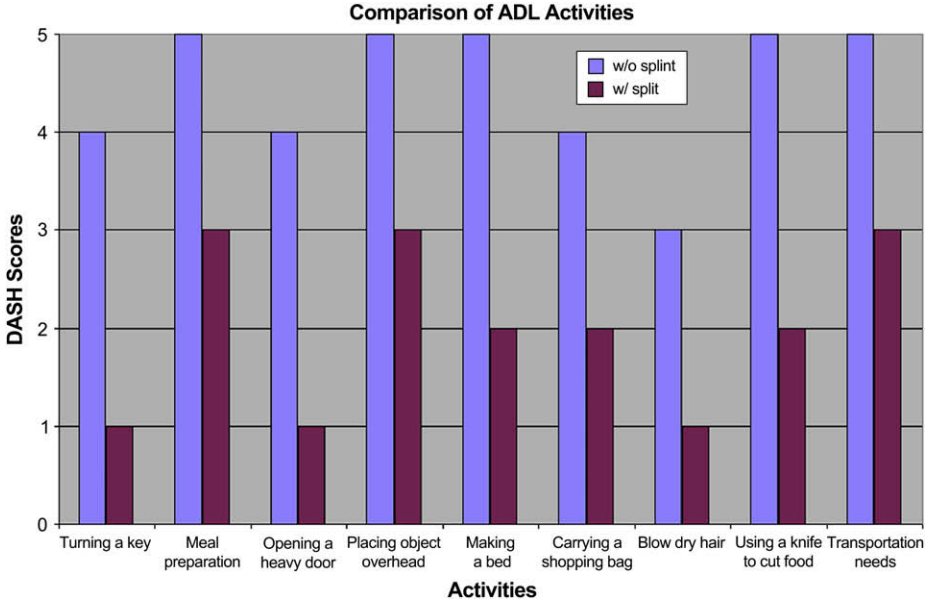

FIGURE 10. *Comparison of disability during activities of daily living on Disability of the Arm, Shoulder, and Hand (1—No difficulty, 2—Mild difficulty, 3—Moderate difficulty, 4—Severe difficulty, 5—Unable).*

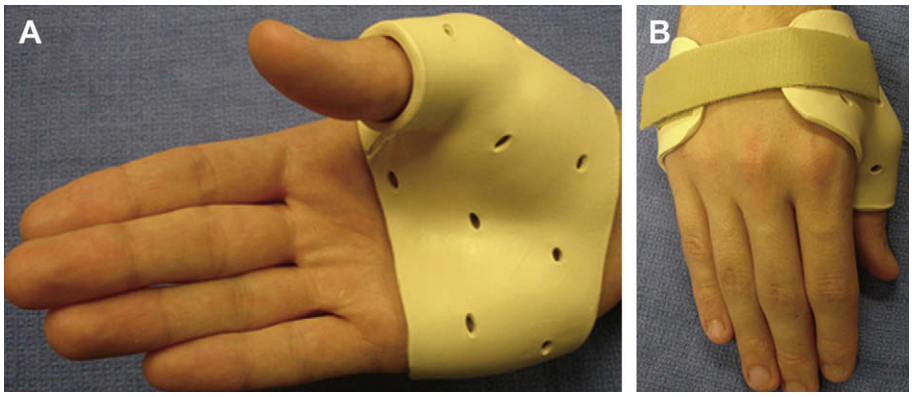

FIGURE 11. *Example of thumb spica base with ulnar portion of hand included (patient not pictured).* ***A.*** *Palmar view.* ***B.*** *Dorsal view.*

nature of the splint material presents challenges. The slick texture of the splinting material requires the use of a supplemental material to increase friction during functional use. The low temperature thermoplastic material also makes it difficult to perform activities in the presence of extreme temperatures, such as cooking. Finally, there is the potential for poor stability of the splint if the thumb amputation level is at or proximal to the MCP joint of the thumb. Stability can be improved by extending the base of the splint to include the ulnar portion of the hand. The splint can then be secured by attaching a hook and loop strap from the ulnar to radial portion of the base (Figure 11). Despite these limitations, we feel we have presented a viable treatment option for patients with partial thumb amputations and further investigation with a larger sample population is warranted.

CONCLUSIONS

In this case study, the use of a thumb opposition splint enhanced the self-reported function of a patient after a partial thumb amputation and improved the patient's perception of disability. The greatest improvement in function occurred during the first three months after initial use; however, improvement was sustained over a period of one year. Using a thumb opposition splint may help improve a patient's ability to participate in ADL activities and enhance their lifestyle long before a permanent prosthesis is appropriate.

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Quiz: Article # 118

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#1. The following was/were measured throughout the study
   a. impairment
   b. disability
   c. impairment and disability
   d. neither impairment nor disability

#2. The design of the study can best be described as
   a. a case study
   b. an N of 1 study
   c. a randomized clinical trial
   d. a retrospective study

#3. The splint was
   a. designed with cosmesis as its primary consideration
   b. a prosthetic devise motorized by a hidden micro chip style battery
   c. constructed of materials not readily available to most hand clinics
   d. constructed of materials readily available to most hand clinics

#4. The primary functional measure was
   a. the AMA impairment scale
   b. pinch meter scores
   c. the DASH
   d. the Purdue Pegboard

#5. The splint provided improved hand function
   a. false
   b. true

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